



Overview

Spaceflight Experience and Medical Care

Overview

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All spaceflights regardless of their length and crew tasks require some level of in-mission medical capabilities. Transitioning between gravity and microgravity environments, coupled with living in a closed loop environment, may result in a variety of changes and risks. Physiological effects such as fluid loss and head congestion can occur when adapting to microgravity. These effects typically occur within a predictable timeframe and afflict all crewmembers to some degree. In addition, due to the nature of spaceflight, a multitude of psychological conditions can present. To ensure mission success and a positive spaceflight experience, human health changes need to be considered and mitigated. Integration of multiple mitigation strategies (including appropriate crew selection, pre-mission quarantine, in-mission medical supplies, training, and ground medical support) will be required to ensure crew health and performance. The vehicle must be designed to accommodate necessary medical actions taking into consideration the medical equipment, crew training, aids and physical space needed. The knowledge and tasking to complete medical actions may be distributed among crewmember(s), medical devices, artificial intelligence systems, robotic systems, or other mechanisms. Integration of these systems is key to providing adequate medical capabilities.

For the purpose of this technical brief, a short mission is defined as ≤ 14 days and a long mission is defined as > 14 days. These are approximate and can be reconsidered based on mission parameters.

Pre-mission		In-mission		Post-mission	
Selection Standards					
	Health Stabilization Program				
		In-mission Medical Treatment & Capabilities	Immediate Post-landing Care		
Longitudinal Health Surveillance					

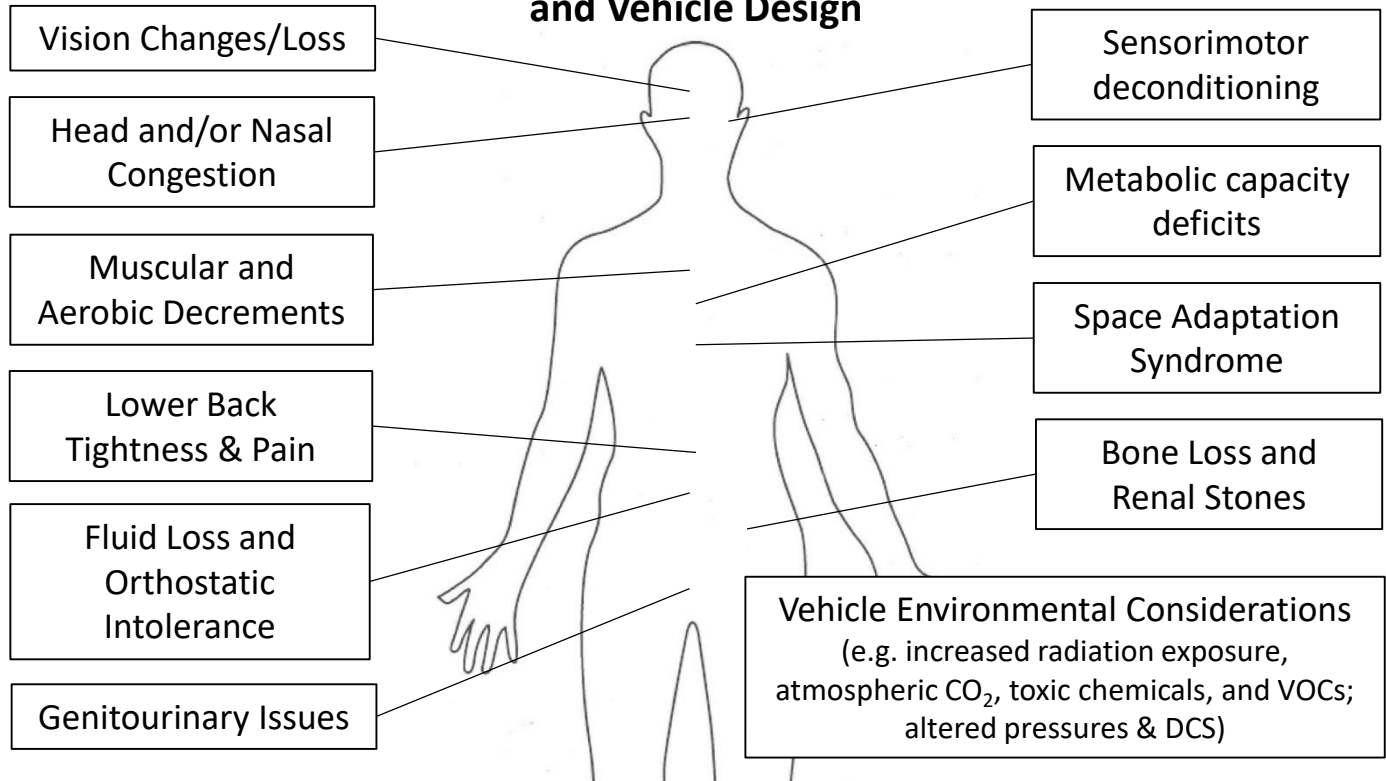
The above table displays the interaction between five key elements that are necessary to promote crew health and performance:

1. Crew Selection Standards
2. Health Stabilization Program (HSP) – [Health Stabilization Program Technical Brief](#)
3. In-mission Medical Treatment & Capabilities – covered in this technical brief
4. Immediate Post-landing Medical Care – i.e. medical care immediately post-flight/post-mission; covered in this technical brief
5. Longitudinal Health Surveillance – [Longitudinal Health Surveillance Technical Brief](#)



Changes During Spaceflight

Background

Prevalent Physiologic Changes
Experienced due to Microgravity
and Vehicle Design

Ensuring the crew has no communicable diseases prior to the mission via a HSP lessens the in-mission impacts. All crewmembers experience the above effects to some extent. Having the appropriate in-mission medical supplies/capabilities is critical to minimizing these effects and maximizing crew performance and experience. In addition, NASA crewmembers are selected through a rigorous set of procedures in order to minimize some of the above effects. For example, certain cardiac and musculoskeletal issues and osteopenia are selected out to enhance mission success.

Reference Documents

- Human System Risk Board Risk Packages – including Orthostatic Intolerance; Radiation; Back Pain; Sensorimotor Alterations; Reduced Muscle Mass, Strength; Reduced Aerobic Capacity; Renal Stone Formation; and, Vision Alterations
- Space Operations Medical Support Training Course: Space Physiology and the Deconditioned Astronaut. NASA JSC, Space Medicine Operations Division
- HSP Technical Brief, Longitudinal Health Surveillance Technical Brief, Orthostatic Intolerance Technical Brief
- Wotring, V. E. Medication use by U.S. crewmembers on the International Space Station. *FASEB J.* 29, 4417–4423 (2015).

NASA Office of the Chief Health & Medical Officer (OCHMO)

This Technical Brief is derived from NASA-STD-3001 and is for reference only.

It does not supersede or waive existing Agency, Program, or Contract requirements.

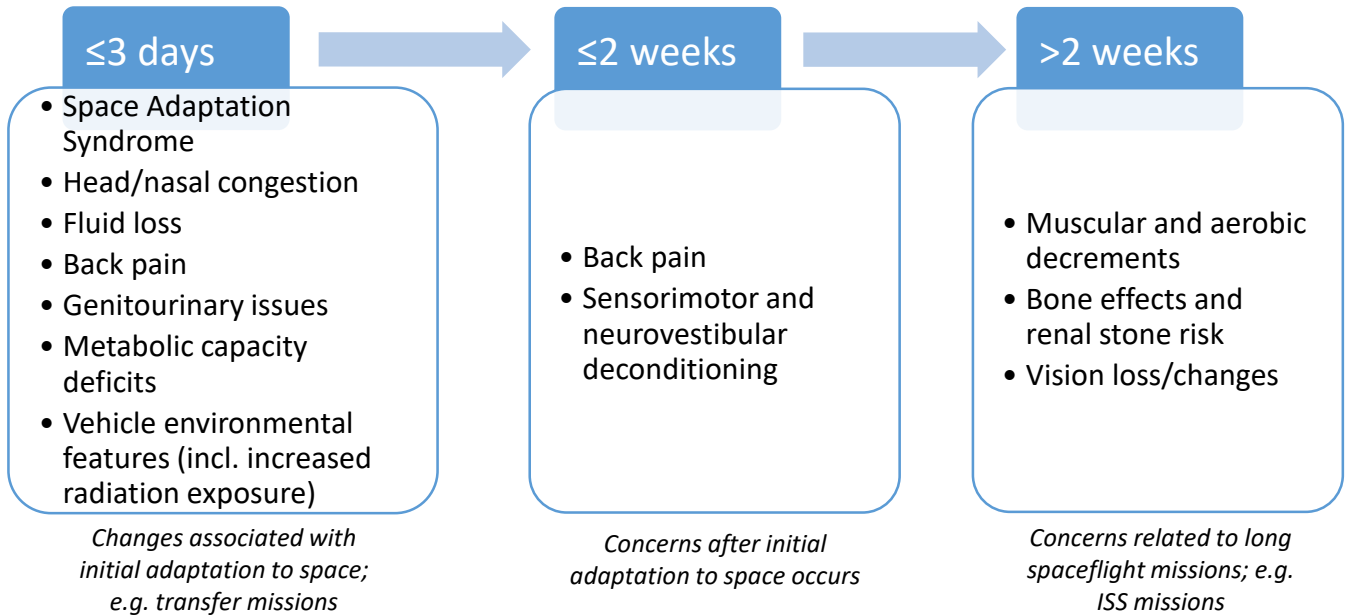


Timeline

Timeline and relevant information for expected conditions

Reference Data

Physiologic Timeline



≤3 Days – changes associated with initial adaptation to space; e.g. transfer missions

- Space Adaptation Syndrome (SAS) – neurovestibular adaptation to microgravity; symptoms include nausea, emesis, headache, malaise, and vertigo; cephalad shift of fluid, resulting in facial “stiffness”
 - Affects 50-70% of crewmembers
 - Treatment: pharmaceutical options, inactivity, head movement exercises, head restraints, 1g orientation and pre-mission training / prophylaxis
- Head/nasal congestion
 - Affects >50% of crewmembers
 - Treatment: pharmaceuticals (congestion or allergy meds)
 - Leading cause of prolonged medication use in-mission
- Fluid loss – 15% reduction in circulating fluid volume, leading to polyuria
 - Affects all crewmembers
 - No in-mission treatment is needed, but the vehicle must be able to accommodate the increased urine output. Countermeasures are needed upon return to gravity to prevent orthostatic intolerance (see [Orthostatic Intolerance Technical Brief](#) for more info)
- Genitourinary issues – subset of crew who experience urinary incontinence or urinary retention
- Increased radiation exposure
 - Not a concern in low Earth orbit, but must be considered for missions travelling outside of the Van Allen Belts





Timeline

Timeline and relevant information for expected conditions

Reference Data



≤2 weeks – concerns after initial adaptation to space occurs

- Lower back tightness & pain (i.e. Space Adaptation Back Pain, SABP) – back pain associated with the physiological changes in spaceflight; SABP is distinguished from other types of back pain if it develops within the first 5 days of the mission
 - Affects 52% of crewmembers
 - Treatments: pharmaceutical options, sleep accommodations that allow for fetal position, and exercise (≥85% pain relief effectiveness for all treatments)

>2 weeks – concerns related to long spaceflight missions; e.g. ISS missions

- Muscular and aerobic decrements – decrease in muscle mass and aerobic capacity over the mission
 - Begin for all crewmembers upon exposure to microgravity, but are only a concern for longer missions: more muscle & aerobic capacity are lost the longer the crew is in microgravity
 - Countermeasures/treatment: exercise – resistive and aerobic
- Bone effects and renal stone risk – microgravity induces bone atrophy, approximated at 1.5%/month with countermeasures; increases calcium lost which impacts renal stone risk
 - Bone effects begin for all crewmembers upon exposure to microgravity, but are only a concern for longer missions – more bone is lost the longer the crew is in microgravity, which leads to a greater renal stone risk
 - Countermeasures/treatment: pharmaceutical options and exercise
- Vision alterations – cephalad fluid shifts lead to disc edema, choroidal folds, globe flattening, and other ophthalmic changes including vision changes that could impact performance
 - 16% of crewmembers show disc edema for 6 month missions
 - Treatment: corrective lenses, and adjustable glasses; potential countermeasures: pharmaceuticals, reduced cabin CO₂, lower Na⁺ intake, limiting resistive exercise
- Increased radiation exposure – An increased risk of developing cancer post mission
 - For more information and techniques to limit radiation exposure, reference this technical brief: [Design for Radiation Protection](#)

Upon re-entry to 1g: descent and landing

- Sensorimotor and neuro-vestibular deconditioning – the brain and neurological systems that control balance and motor skills adapt to microgravity within 2 weeks of spaceflight missions; it takes hours to days for the body to readapt to a gravity environment upon landing, causing balance issues and visual inconsistencies
 - Affects all crewmembers post-landing to some extent; may be severe enough that crew cannot perform functional/operational tasks (e.g. fall recovery)
 - Impacts vehicle design (e.g. displays & controls)
 - Prevention: in-mission exercise provides some benefit
 - Treatment for symptoms similar to SAS





Medical Program Design Guidance

Application Notes

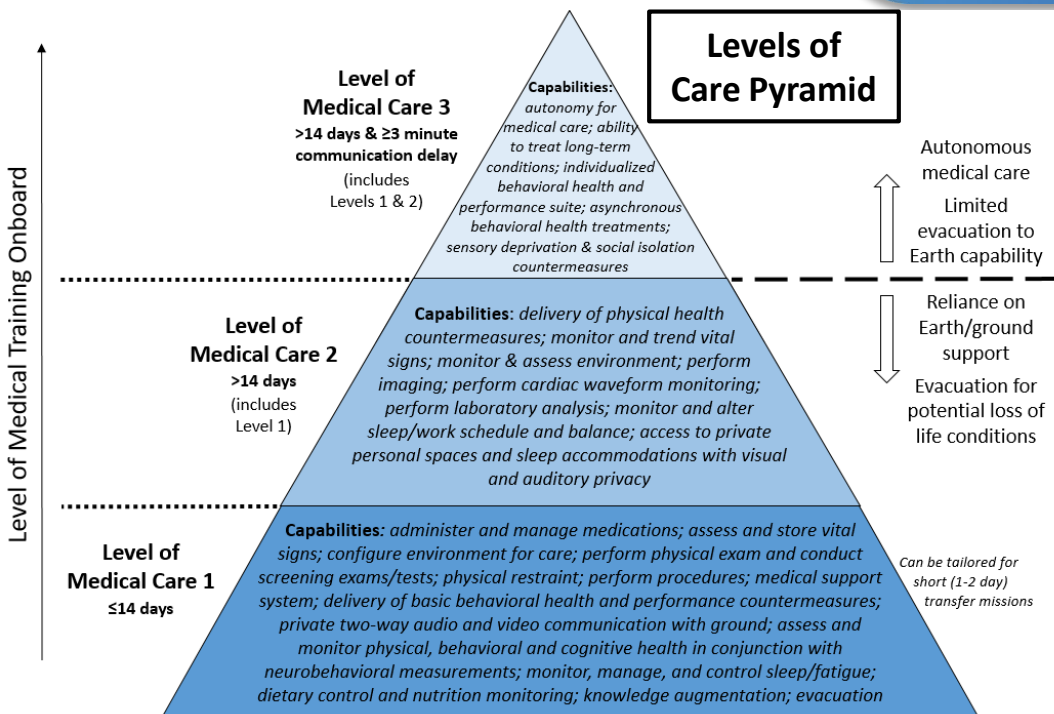
- The importance of the interaction between crew selection, health stabilization programs, longitudinal health surveillance, in-mission medical capabilities and immediate post-mission medical care cannot be overstated. These program aspects, in conjunction with vehicle design, work together to maximize crew health and performance over the mission, while helping to decrease resources and wasted time during the mission. The process begins with crew selection, but is maintained throughout the mission cycle.
- By employing strict selection criteria and selecting out certain conditions, healthier individuals are flown and less risk is present in-mission. If the selection criteria is broadened, then in-mission medical capabilities should accommodate the anticipated conditions and consideration should be given to determine if the conditions are exacerbated by spaceflight.
- Crewmembers should participate in a health stabilization program (HSP) to promote success over the full length of the missions. HSPs may also help reduce the burden of spaceflight adaptation by ensuring the crew will begin missions with near-ideal health from a communicable diseases perspective.
- In an effort reduce the need for in-mission medical care and mitigate the risks of spaceflight, activities should be performed pre-, in-, and post-mission to help the crewmember achieve maximal health (i.e. longitudinal astronaut health surveillance – training, countermeasures, and reconditioning – should be employed). By taking a prevention approach rather than a reactionary approach, total onboard resources and required mission capabilities can be lessened.
- Based on the most common conditions expected and seen during missions, NASA has broken down medical care into levels. These Levels of Medical Care contain conditions required to be treated in-mission, as well as treatment capabilities needed. This program aspect is the most effected if the other three factors are neglected. In other words, if selection criteria, HSP, and occupational surveillance protocols are less strenuous, then more in-mission medical care will be required.



Levels of Care

In-mission Medical Guidance

Application Notes



Levels of Medical Care are influenced by the following:

1. Expected conditions due to spaceflight adaptation (e.g. neurovestibular adaptation, back pain, urinary incontinence, muscle loss, etc.)
2. Pre-flight Health Stabilization Program (e.g. communicable diseases prevention (influenza, cold), vaccinations)
3. Mission architecture (EVAs, decompression protocols, environmental conditions of vehicle, etc.)
4. Crew selection criteria (e.g. cardiovascular conditions, behavioral conditions)
5. Mission duration
6. Distance from Earth & required autonomy
7. Destination / gravitational environment

See full list of conditions for more details/options.

Some conditions in the LoC present due to the microgravity environment or are treated differently compared to terrestrial practices. These conditions include, but are not limited to:

- **Sleep Loss and Alertness:** circadian shifts and abnormal sleeping orientations lead to loss of sleep in crewmembers and subsequent alertness deficits
 - Treatment may be as simple as sleep aids (~71% use in crew; 10x higher than use in adult ambulatory medicine) and alertness aids (~21% use in crew)
 - Sleep aids are the leading cause of acute medication use in-mission
- **Headaches:** present at increased incidence due to elevated CO2 levels, pressure changes, and other non-spacecraft-associated factors
- **Joint and Muscle Pain:** increased incidence due to EVAs and exercise equipment used during the missions

While most conditions can be treated as they are on Earth, mass, size, and capability restrictions may limit the scope of in-mission medical treatment. Thus, prioritization should be given to medications that can serve multiple purposes and do not advance the physiologic effects of a crewmember in space.

Extensive consideration should be given to all medications administered in-mission due to the closed-loop environment. For example, a medication that increases urinary calcium output is not only putting the crewmember at a greater risk of developing kidney stones, but may also cause further stress on the vehicle's water reclamation system. Another consideration is the pharmaceutical treatment pathway. Sprays, for example, may not be as desirable as solid medications due to the lack of gravity.

Side effects of medications should also be considered due to the bevy of spaceflight-induced changes on the human. For example, cardiovascular deconditioning and fluid loss is seen in every crewmember in-mission. Thus, medications that produce effects such as cardiac depression or vasodilation should be avoided.



Level of Medical Care 1

In-mission Conditions Required to be Treated

The following list of in-mission conditions must be able to be treated on short-duration missions¹ (≤ 14 days). They are taken from NASA's Levels of Care.

Application Notes

Spaceflight-induced Conditions	Neurovestibular adaptation, including nausea and emesis
	Headache
	Back pain
	Nasal congestion
	Urinary incontinence
	Urinary retention
Other Physical Conditions	<i>Gastrointestinal</i> : indigestion, constipation, diarrhea, hemorrhoids
	<i>Ear, nose, throat & mouth</i> : acute sinusitis, nose bleed, otitis externa/media, mouth ulcer
	<i>Skin</i> : skin abrasion, skin laceration, skin rash, skin infection
	<i>Genitourinary</i> : urinary tract infection, abnormal uterine bleeding, vaginal yeast infection
	<i>Other</i> : eye abrasion, allergic reaction, paresthesia, choking / obstructed airway, anaphylaxis, sepsis, medication overdose / adverse reaction
Psychological, Cognitive, or Behavioral Conditions	Acute stress
	Anxiety / panic
	Insomnia / sleep disturbances / circadian dysregulation
	Mood disturbance (e.g. irritability)
	Cognitive disturbance
	Adjustment reaction
	Interpersonal conflict (i.e. team, ground, family)

¹Conditions can be tailored (i.e. added in or taken out) according to the mission profile and spacecraft design; see slide 8



Additional Conditions in Level of Medical Care 1

Application Notes

Based on the overall mission architecture assessment (activities, duration, vehicle design, etc.), the following conditions may need to be treated in flight

A Health Stabilization Program minimizes the risk of the following conditions, but they may develop in spite of rigorous protocols:

- Pharyngitis
- Gastroenteritis
- Influenza
- Respiratory infection
- Herpes zoster reactivation

Some conditions are dependent on spacecraft design, mission architecture, launch and landing loads, and mission activities. Thus, this subset of conditions may not apply to every spaceflight mission. Conditions from this list that are required to be treated should be tailored to each program. These conditions include:

- Muscular sprain/strain
- Joint sprain/strain (shoulder, elbow, wrist, hip, knee, ankle)
- Dislocation (finger, elbow, shoulder)
- Back, neck, head, chest, abdominal injury
- Traumatic hypovolemic shock
- Neurogenic shock
- Fracture (wrist, hip/proximal femur, lumbar spine)
- Lower extremity stress fracture
- Barotrauma
- Hearing loss
- Decompression Sickness, secondary to EVA
- Fingernail delamination
- Burns, secondary to fire
- Smoke inhalation
- Altitude sickness
- Toxic exposure: ammonia
- Acute Radiation Syndrome
- Eye penetration (foreign body)
- Eye chemical burn

Rigorous crew selection should prevent the following list of conditions from occurring. However, if NASA-level crew selection criteria is not used, these conditions must be able to be treated in-mission, or can be mission-ending:

- Hypertension
- Angina / myocardial infarction
- Sudden cardiac arrest
- Atrial fibrillation / atrial flutter
- Stroke (CVA)
- Cardiogenic shock, secondary to MI
- Seizures
- Acute arthritis



Level of Medical Care 1

Required In-mission Capabilities

The following list of in-mission capabilities (i.e. procedures, protocols, vehicle accommodations, etc.) are required for short-duration missions¹ (≤ 14 days). They are taken from NASA's Levels of Care.

Application Notes

Administer and manage medications

Assess and store vital signs

- e.g. blood pressure, oxygen saturation, heart rate, respiratory rate, etc.

Perform physical exam and conduct screening exams/tests

Perform procedures

- E.g. inserting a catheter, suturing, blood draw, etc.

Delivery of basic behavioral health and performance countermeasures

- e.g. recreational time, books, movies, music, crew care packages, access to fresh produce, Earth viewing opportunities

Assess and monitor physical, behavioral and cognitive health with neurobehavioral measurements

- e.g. PMC, PPC, computer-based programming, cognitive and psychological assessments, etc.

Monitor, manage, and control sleep/fatigue

Dietary control and nutrition monitoring

Evacuation

Configure environment for care

Physical restraints for physiological and psychological use

- e.g. Grey tape, countermeasure restraint systems

Medical support system (i.e. inventory monitoring/maintenance, etc.)

Private two-way audio and video communication with ground

- with ground medical support, family, and crew support system

Knowledge augmentation

- e.g. in-mission computer-based therapy, smart medical devices, just-in-time training, etc.

Procedures & Protocols

Vehicle Accommodations

¹Capabilities can be tailored (i.e. added in or taken out) according to the mission profile and spacecraft design



Level of Medical Care 2

In-mission Conditions Required to be Treated

Application Notes

The following list contains additional in-mission conditions that must be able to be treated on long-duration missions¹ (>14 days). They are taken from NASA's Levels of Care.

Physical Conditions

Ophthalmic: VIIP/SANS, retinal detachment, acute glaucoma, eye corneal ulcer, eye infection

Dental: caries, dental abscess, exposed pulp, dental filling loss, dental avulsion, dental crown loss

Abdominal: abdominal wall hernia, nephrolithiasis, acute pancreatitis, acute cholecystitis / biliary colic, small bowel obstruction, appendicitis, acute diverticulitis, acute prostatitis

Other: Acute Compartment Syndrome

Psychological, Cognitive, or Behavioral Conditions

Work overload / burnout / exhaustion

Lack of meaningful work and/or monotony

Apathy / low motivation

Grief reaction

Depression

Delirium

Relationship problems (family, crew, mission support personnel)

Adjustment, mood, anxiety, trauma-related, stress-related, and neurocognitive disorders

Psychosis

¹Conditions can be tailored (i.e. added in or taken out) according to the mission profile and spacecraft design; see slide 8



Levels of Medical Care 2 & 3

Required In-mission Capabilities

The following list of additional in-mission capabilities (i.e. procedures, protocols, vehicle accommodations, etc.) are required for long-duration missions¹ (>14 days). They are taken from NASA's Levels of Care.

Asterisked () conditions are capabilities required only for Level of Medical Care 3.*

Delivery of physical health countermeasures

- countermeasures intended to counteract cardiovascular, musculoskeletal, and neurovestibular deconditioning; e.g. exercise

Monitor and trend vital signs

Perform imaging

Perform cardiac waveform monitoring

Perform laboratory analyses

Monitor and alter work/rest schedule and balance

Individualized behavioral health and performance countermeasures suite*

- e.g. each crewmember has access to their own personal device with entertainment, photos, audio, personal video clips, virtual reality, store and forward communications with family and friends

Evidence-based asynchronous behavioral health treatment protocols available on electronic devices*

Medical devices for treating neurobehavioral disorders*

- e.g. TES

Sensory deprivation countermeasures*

- e.g. novelty, virtual reality, greenhouse

Social isolation countermeasures*

- e.g. games, observance of important holidays/events

Monitor and assess environment

Access to private personal spaces and sleep accommodations with visual and auditory privacy

Procedures & Protocols

Vehicle
Accommodations

¹Capabilities can be tailored (i.e. added in or taken out) according to the mission profile and spacecraft design

**Example Medical Kit**

Underlined resources are the minimum suggested for short-duration missions

Application Notes

Medications/ Treatments ¹	Examples	Examples of Associated Conditions ²
Adhesives	Dermabond	Skin laceration
Analgesics	<u>Acetaminophen</u> , Benzocaine, Hydrocodone/Acetaminophen HP, Hydromorphone	Back pain, headache, sprain, acute arthritis, fracture, nephrolithiasis, small bowel obstruction
Anesthetics	<u>Dental eugenol anesthetic</u> , Ketamine, <u>Lidocaine jelly</u> , Lidocaine plain, Lidocaine w/ Epinephrine	Skin laceration, dental avulsion
Antibiotics	<u>Amoxicillin</u> , <u>Azithromycin</u> , <u>Bacitracin</u> , <u>Bactrim</u> , Ceftriaxone, <u>Ciprofloxacin</u> , <u>Clindamycin</u> , Ertapenem, Erythromycin, Levofloxacin, <u>Metronidazole</u> , <u>Moxifloxacin</u> , <u>Mupirocin</u> , Tobramycin	Acute sinusitis, pharyngitis, urinary tract infection, skin infection, appendicitis, acute diverticulitis, prostatitis
Anticonvulsants	<u>Phenytoin</u>	Seizures
Antifungals	<u>Clotrimazole cream</u> , <u>Fluconazole</u>	Skin infection, vaginal yeast infection
Antihistamines	Cetirizine, <u>Diphenhydramine HCl</u> , Loratadine, <u>Pseudoephedrine</u>	Allergic reaction
Antiseptics	Carbamide peroxide, iodine, silver nitrate sticks	Skin laceration, skin infection, traumatic injuries
Antivirals	<u>Valacyclovir</u>	Respiratory infection, influenza, herpes zoster reactivation
Behavioral Medications	Aripiprazole, Diazepam, <u>Lorazepam</u> , Sertraline, Venlafaxine XR, Ziprasidone HCl	Anxiety, depression
Cardiovascular Medications	Atropine, Epinephrine, Lidocaine Cardiac, Metoprolol, Nitroglycerin	Myocardial infarction, angina, hypertension, anaphylaxis
Corticosteroids	<u>Fluocinonide</u> , Fluticasone	Allergic reaction, skin infection
Decongestants	<u>Oxymetazoline</u> , <u>Pseudoephedrine</u>	Headache, nasal congestion, respiratory infection
Gastrointestinal Medications	<u>Bisacodyl</u> , <u>Bismuth subsalicylate</u> , Glycopyrrolate, <u>Loperamide HCl</u> , Meclizine, Omeprazole, <u>Ondansetron</u> , <u>Promethazine</u> , <u>Ranitidine</u>	Space Motion Sickness, diarrhea, constipation, indigestion, gastroenteritis
Genitourinary Medications	Tamsulosin	Urinary retention
Glucocorticoids	<u>Dexamethasone</u> , Prednisone	Nasal congestion, respiratory infection, acute arthritis
Hormonal Medications	Ethinyl Estradiol, <u>Estrogen</u> , Norgestrel	Abnormal uterine bleeding
Hypnotics	<u>Ambien</u> , Melatonin	Insomnia / sleep disorder
Nasal Medications	<u>Nasal moisturizer (saline nose spray)</u>	Nasal congestion
Non-steroidal anti-inflammatory drugs	<u>Aspirin</u> , <u>Ibuprofen</u> , <u>Ketorolac</u>	Back pain, strain, sprain, acute prostatitis
Ophthalmic Medications	<u>Cyclopentolate</u> , <u>eye lubricant (Refresh Artificial Tears, Refresh Eye Ointment)</u> , <u>Fluorescein</u> , Tropicamide	Eye irritation, eye chemical burn, eye abrasion
Pulmonary Medications	Albuterol	Smoke inhalation
Stimulants	<u>Modafinil</u>	Insomnia / sleep disorder

Note: This list does not include crewmember personal medications, such as antihypertensives, statins, etc.

¹This list originates and is adapted from IMM Data Request D-20190918-419.

²The listed conditions are not an exhaustive list of the conditions that the medication/treatment type can be used for.



Example Medical Kit

Underlined resources are the minimum suggested for short-duration missions

Application Notes

Medical Equipment & Technology ¹	Examples	Examples of Associated Conditions ²
Ambu bag and mask	--	Stroke, sudden cardiac arrest
Antiseptic wipes	BZK wipes	Skin laceration, abrasion
AED	--	Sudden cardiac arrest
Bandages	<u>Band-Aids (2x3, knuckle, dot, strip)</u> ; burn, clear, and nonstick bandages	Skin laceration, burn secondary to fire, traumatic injury
Biohazard trash bags	--	Nose bleed, skin laceration
<u>Blood oximeter</u>	--	Altitude sickness, choking /obstructed airway, smoke inhalation
Blood pressure /ECG monitor	Monitor, cuffs (large & small), electrodes	Hypertension, atrial fibrillation/flutter, myocardial infarction, sudden cardiac arrest
Camera	Photo camera, camcorder	Traumatic injury, skin infection
Countermeasure Restraint System	Treatment restraint in microgravity	Activities that require accurate administration of treatment by one crew member to another
Compressive bandages	<u>Ace Bandage (2", 3", 4")</u>	Sprain, strain, dislocation
Cotton goods	Balls, pellets, and swabs	Skin laceration, abrasion, nose bleed, traumatic injury
DCS examination scorecard	--	Decompression Sickness
Dental equipment	Adhesive, adhesive tip, amalgam file, crown remover, elevator (301 (I), 34S (J)), explorer/probe, forceps (10S (A), 151A (B), 17 (C)), mirror, syringe; temp tooth filling	Dental abscess, exposed pulp, dental crown loss
Ear curette	--	Otitis externa/media
<u>Ear wick</u>	--	Otitis externa/media
Endotracheal (ET) tube and equipment	ET tube (7.0/7.5, 7.0/8.0); Bougie ET introducer, ET stylet	Sudden cardiac arrest, stroke
EpiPen®	--	Anaphylaxis
Eye wash equipment	<u>Spacecraft eye wash system; eye wash goggles, tubing, and waste water bag</u>	Eye chemical burn, eye penetration
Forceps	Smooth and toothed (EE) forceps	Skin laceration, traumatic injury
Gauze pads and rolls	--	Skin laceration, traumatic injury
Gloves	Small, medium, and large pairs of nitrile gloves; small, medium, and large pairs of sterile gloves	Skin laceration, hemorrhoids, traumatic injury, urinary retention
Hemostats	--	Traumatic injury
Hot and cold pads	--	Back pain, strain, sprain, dislocation

¹This list originates and is adapted from IMM Data Request D-20190918-419.

²The listed conditions are not an exhaustive list of the conditions that the medication/treatment type can be used for.

**Example Medical Kit**

Underlined resources are the minimum suggested for short-duration missions

Application Notes

Medical Equipment & Technology ¹	Examples	Examples of Associated Conditions ²
Intraosseous equipment	IO device starter kit and injection device	Traumatic injury, sudden cardiac arrest, stroke
Intubating Laryngeal Mask Airway (ILMA)	ILMA cue card, ET tube (7.0/7.5, 7.0/8.0), hardware, stabilizing rod, and syringe	Sudden cardiac arrest, stroke
Intravenous (IV) Equipment	<u>IV administration set, cap, catheter</u> (14G, 18G, <u>20G</u> , 22G), fluids, and pressure infuser	Traumatic injury (burns from fires, hypovolemic shock), stroke, sepsis, small bowel obstruction
Laryngoscope blade & handle	--	Sudden cardiac arrest, stroke
Maximum Absorbency Garment (MAG)	--	Urinary incontinence
Medical tape	--	Skin laceration, traumatic injury
Nasal equipment	Nasal airway (6MM, 7MM) and packing	Sudden cardiac arrest, stroke
Needle	23G, 25G; needle driver (AA) and plastic	Traumatic injury
Ophthalmic equipment	Eye shield, eye simulator cornea, <u>panoptic ophthalmoscope</u>	Eye abrasion, eye corneal ulcer, acute glaucoma
Oral airway	--	Sudden cardiac arrest, stroke
Otoscope	<u>Handle, head, disposable specula, and USB cable</u>	Otitis externa/media
Oxygen mask (resuscitation mask) and tubing	--	Sudden cardiac arrest
<u>Penlight</u>	--	Dental abscess, dental avulsion
Pregnancy test	--	Abnormal uterine bleeding
<u>Psychotherapy</u>	--	Anxiety, depression, behavioral emergency
Scalpel	Scalpel #11 (blade and handle)	Dental abscess, Compartment Syndrome
Scissors	Trauma scissors	Skin laceration, traumatic injury
Skin stapler, with remover	--	Skin laceration, traumatic injury
Sharps container	--	Skin laceration, traumatic injury, dental abscess, Compartment Syndrome
Space Anticipation Glasses	--	SANS/VIIP
Splints	Arm, finger, and leg	Dislocation
Sterile water	--	Skin laceration, eye chemical burn, traumatic injury
<u>Stethoscope & related ear pieces</u>	--	Respiratory infection, atrial fibrillation
Suction equipment	Suction cartridge, device, device collection bag, device syringe, tip - mouth (curette), and tubing (ET and gastric tubes)	Choking /obstructed airway, traumatic injury

¹This list originates and is adapted from IMM Data Request D-20190918-419.

²The listed conditions are not an exhaustive list of the conditions that the medication/treatment type can be used for.



Example Medical Kit

Underlined resources are the minimum suggested for short-duration missions

Application Notes

Medical Equipment & Technology ¹	Examples	Examples of Associated Conditions ²
Surgical lubricant	--	Traumatic injury
Surgical tools kit	--	Traumatic injury
Sutures & related equipment	<u>Absorbable Suture 3.0</u> , <u>Nylon Suture 2.0 & 5.0</u> ; suture scissors	Skin laceration, abrasion
Syringes	3CC, 5CC, 10CC, 35CC, 60ML	Traumatic injury, atrial fibrillation, small bowel obstruction
<u>Thermometer</u>	--	Pharyngitis, influenza, appendicitis
Tongue depressor	--	Respiratory infection, pharyngitis
Tonometer	--	VIIP/SANS, eye infection
<u>Tourniquet</u>	--	Traumatic injuries
Ultrasound and related equipment	Ultrasound machine, technical equipment, and gel	Acute cholecystitis/biliary colic, abdominal wall hernia, acute pancreatitis
Urinary catheter	Coude, Foley, short, straight	Urinary retention
Urinary collection bag	Leg bag	Urinary retention
<u>Urine Chemstrips</u> and color chart	--	Urinary tract infection
Variable Oxygen System (VOS) and related equipment	VOS and VOS intubated patient hardware	Decompression Sickness, sudden cardiac arrest, stroke
Wound packing	--	Traumatic injury

¹This list originates and is adapted from IMM Data Request D-20190918-419.

²The listed conditions are not an exhaustive list of the conditions that the medication/treatment type can be used for.



Post-landing Considerations and Crewmember Treatment

Application Notes

Pre-landing Preparations

- Crewmembers can take measures pre-landing to mitigate symptoms post-landing. These measures may include prophylactic medication use, fluid loading, and orthostatic intolerance compression garments.

Neurovestibular

- Cause / Background: neurovestibular system is still adapted to the spaceflight environment (i.e. microgravity)
- Symptoms: vertigo; unstable gait; nausea; vomiting
- Medical Recommendations & Treatment: medications (e.g. meclizine, promethazine); avoid rapid head movements; slow, progressive increase in activity; rest

Cardiovascular

- Cause / Background: fluid loss from initial adaptation to space; crewmember has lost 12-15% of their blood volume
- Symptoms: orthostatic intolerance; decreased blood pressure; increased heart rate; nystagmus and/or blurry vision; nausea; weakness/malaise; syncope
- Medical Recommendations & Treatment: OI compression garment (may already be donned); oral fluids (as tolerated); normal saline bolus; medications to treat symptoms; rest
 - Due to fluid loss & possibly dehydration, IVs can be challenging to start. Thus, ground crew personnel need to be prepared appropriately.

Musculoskeletal

- Cause / Background: weightlessness causes bone and muscular atrophy; may be counteracted by in-mission countermeasures, such as exercise
- Symptoms: weakness; fatigue; poor coordination; impaired physical abilities; feeling of heaviness; slow & deliberate movements; muscle pain due to gravitational forces (esp. back aches from spinal recompression)
- Medical Recommendations & Treatment: assistance with ambulation; rest; long-term rehab and physical therapy may be needed

Vehicle Induced Trauma and Toxic Exposures

- Spaceflight re-entries and landings may result in traumatic injuries to the crew (e.g. fractures, neck injuries, etc) or exposures to toxic chemicals (e.g. hydrazine, etc.). Upon landing, the ground medical personnel must be able to accommodate and care for a crewmember who incurs injury or exposure due to the vehicle operations.



Egress is often difficult for crewmembers upon landing. Assisted egress will most likely be needed for missions >2 weeks.